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(54) Abstract Title
High pressure plunger pump

(57) A high-pressure plunger pump for high-pressure fuel pump capable of varying a pump discharge rate thereof, wherein a small back pressure chamber (62) is provided to close the end parts of sliding holes (8, 108, 208) for suction check valve discs (51, 151, 251), the small back pressure chamber (62) communicates with a feed fuel path (4) selectively by opening and closing its port hole (61) by drive parts (71, 471) of small solenoid switching valves (7, 407) and, when the suction check valve discs are operated, the feed fuel discharged through the port hole (61) of the small back pressure chamber (62) is discharged to a suction port (26) of a pump chamber (2) so as to replace the feed fuel inside the small back pressure chamber (62) sequentially with new one, whereby, because a small solenoid switching valve may be used, a high-speed response is enabled, production cost can also be minimized, follow-up to electric signals can be made accurate, and a pump discharge can be controlled precisely.

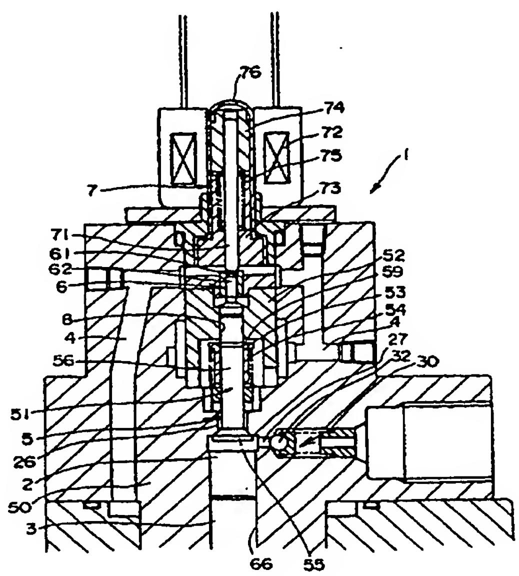

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Fig. 1

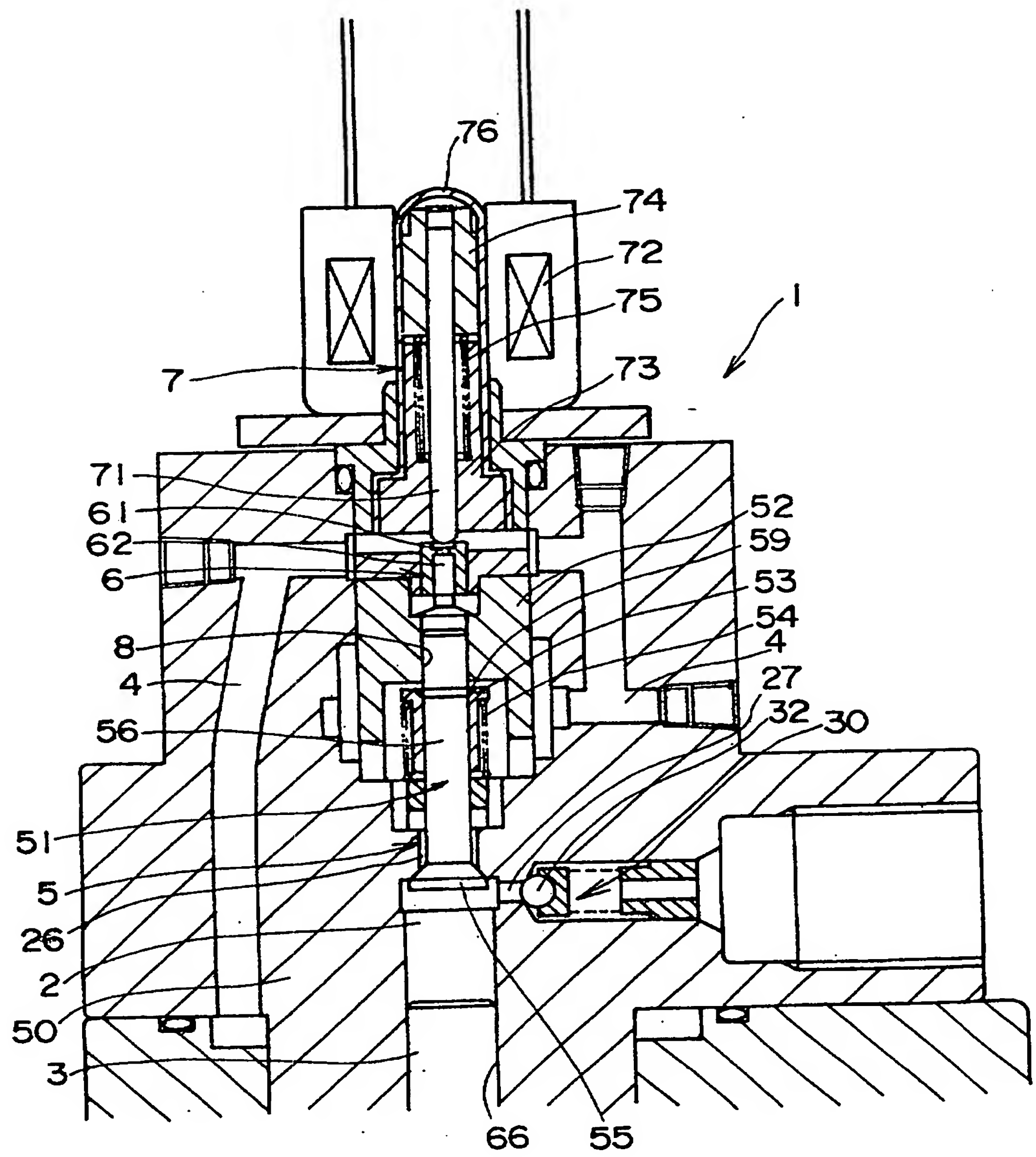
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Fig. 2

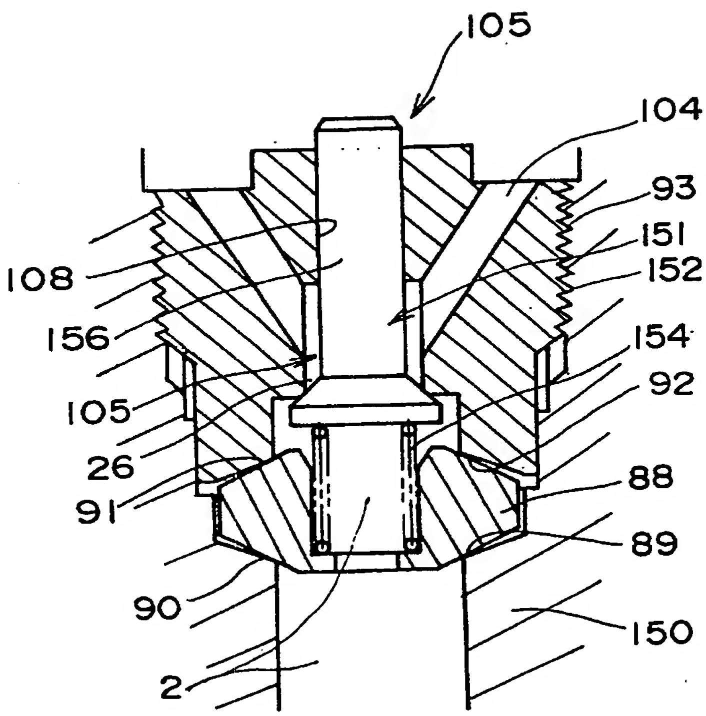

Fig. 3

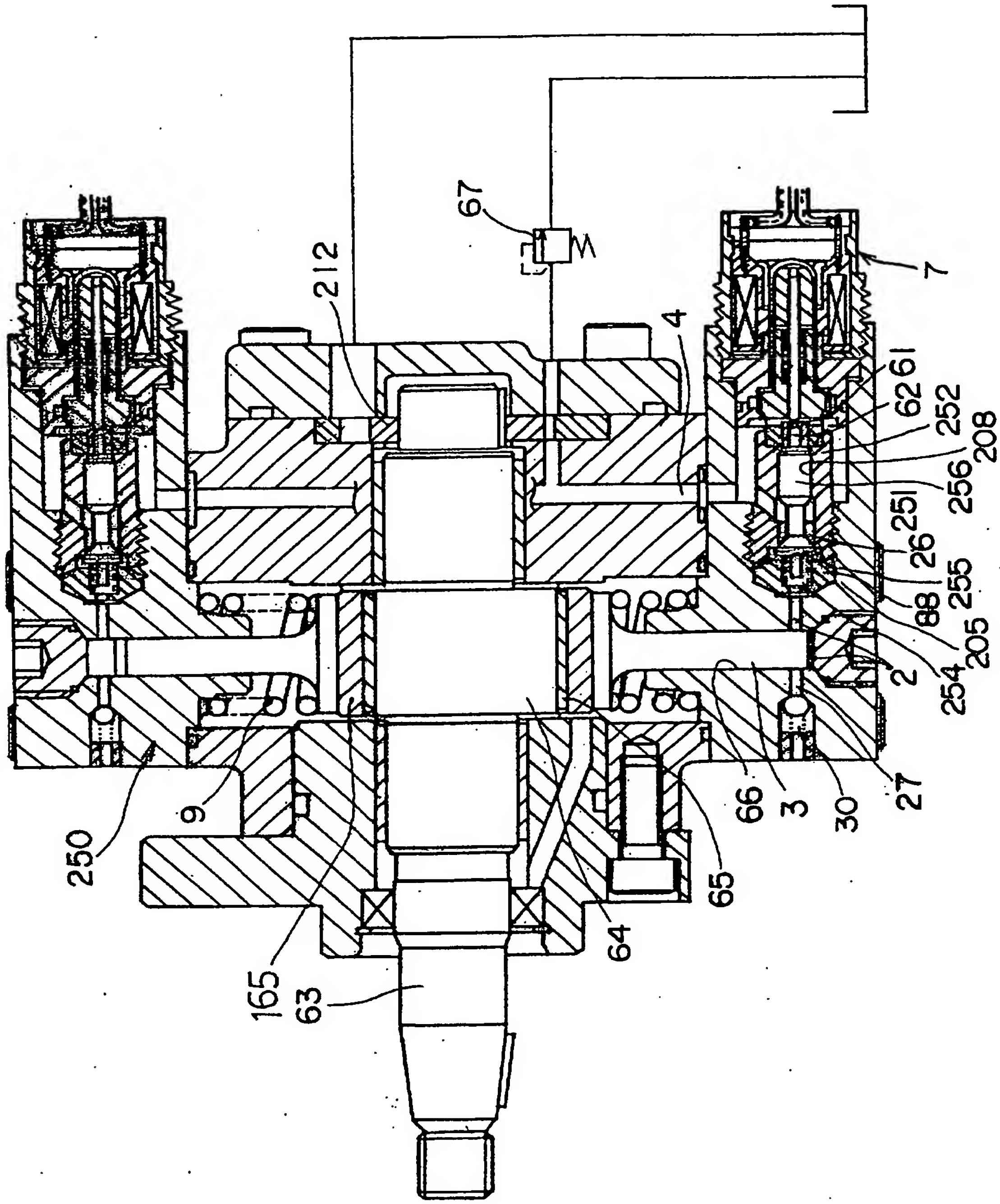
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Fig. 4

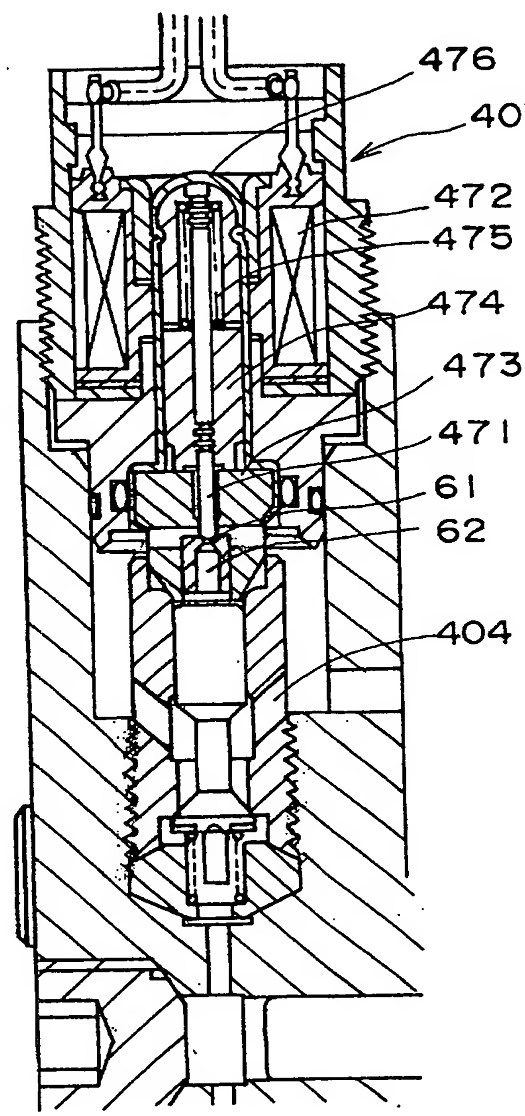


Fig. 5

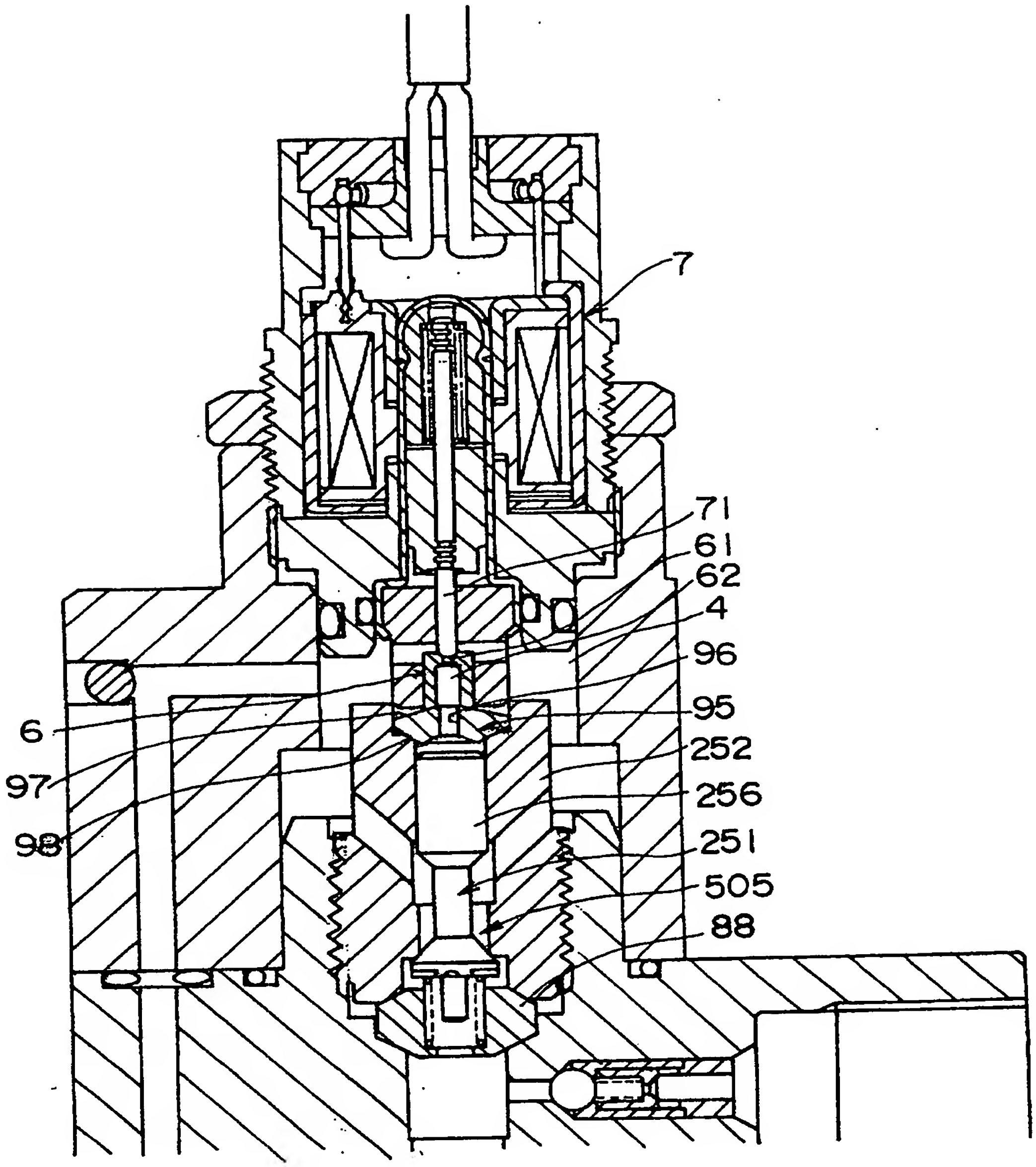


Fig.6

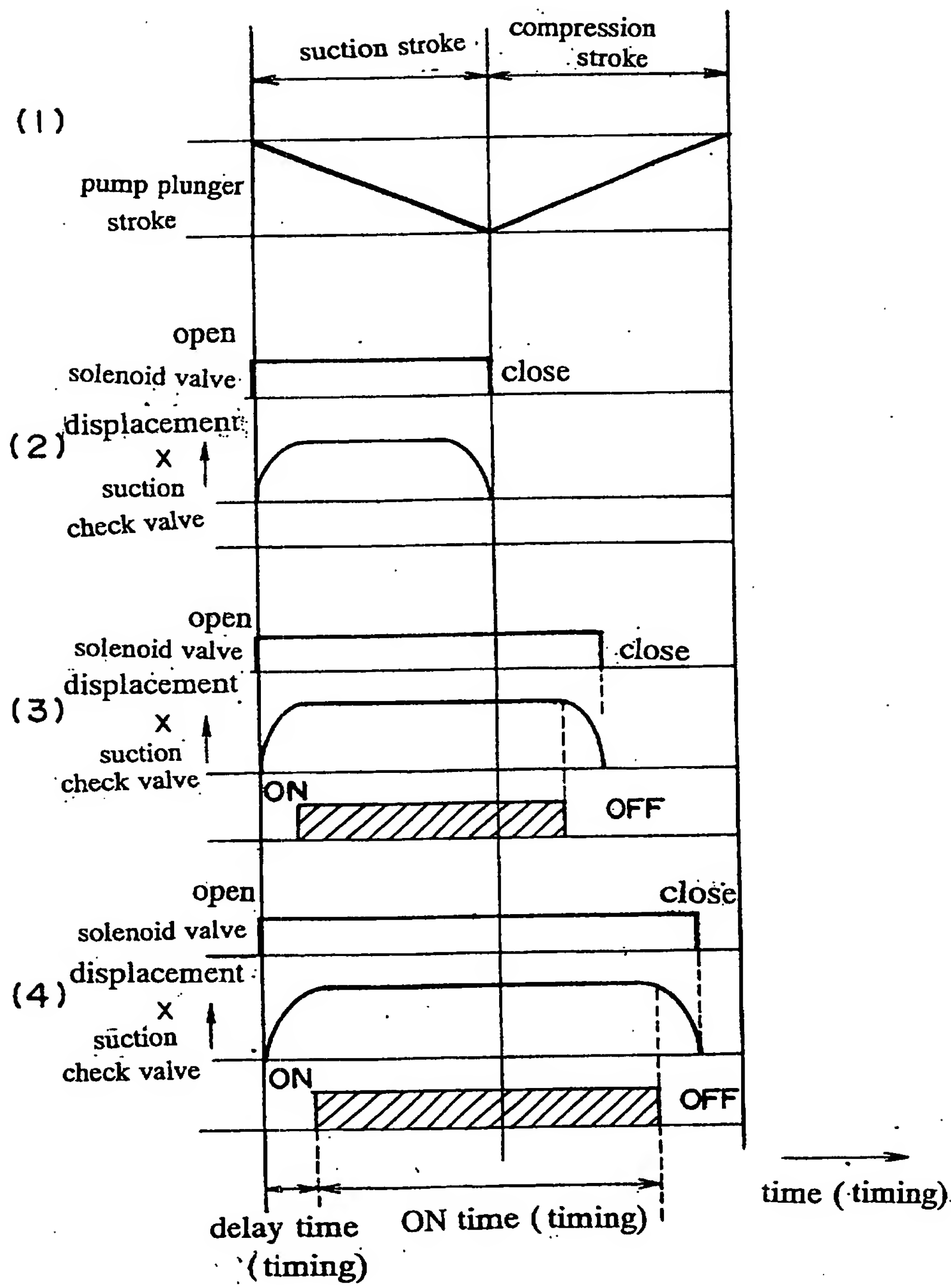
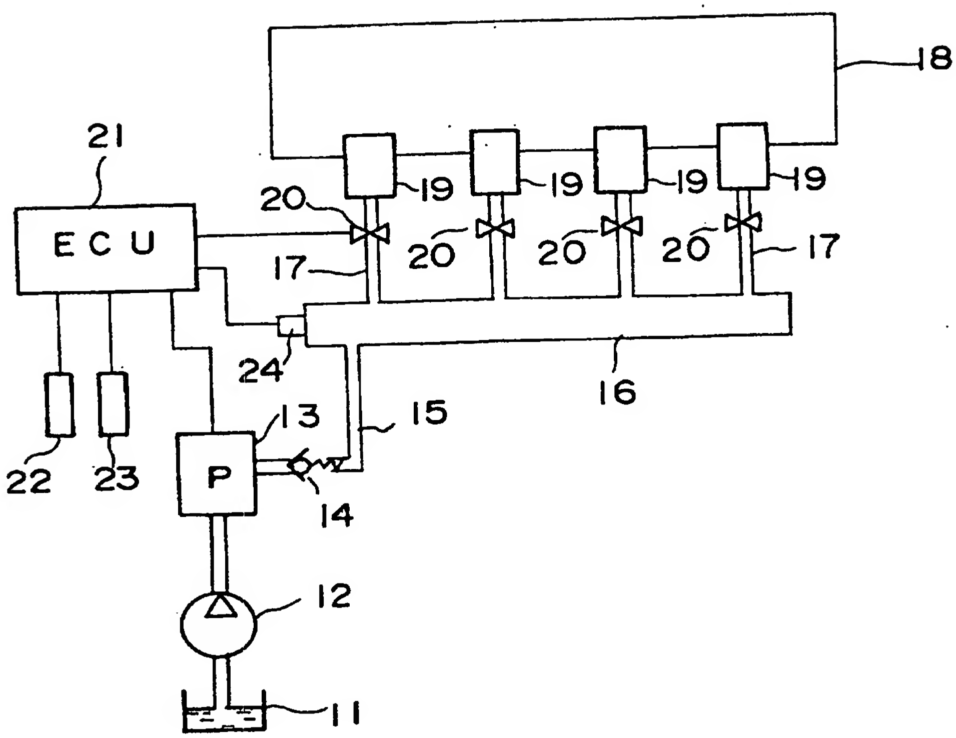

suction stroke
compression stroke
(1)
pump plunger stroke
open
solenoid valve
close
(2)
displacement
x
suction check valve
open
solenoid valve
close
(3)
displacement
x
suction check valve
ON
OFF
open
solenoid valve
close
(4)
displacement
x
suction check valve
ON
OFF
time (timing)
delay time (timing)
ON time (timing)

Fig. 7



SPECIFICATION

TITLE OF THE INVENTION

HIGH PRESSURE PLUNGER PUMP

TECHNICAL FIELD

The present invention relates to a variable discharge high-pressure plunger pump suitable for controlling a high-pressure fuel and capable of çontrolling of varying a pump discharge rate thereof, particularly it relates to a control method of a high-pressure plunger pump suitable for pumping a high-pressure fuel into an accumulator or a common rail of a common rail type fuel injection system.

BACKGROUND TECHNOLOGY

A fuel injection system of the type shown in Fig. 7 includes a high-pressure tubing which forms a high-pressure fuel accumulator referred to as common rail was devised as a fuel injection system for diesel engines or gasoline engines, and an accumulated fuel is injected into cylinders of the engine through electro-magnetic injector, as disclosed in Japanese unexamined publications Nos. 6-257533 and 1-73166 (cores. to U.S.Pat.5,197,438).

The conventional high-pressure fuel pump disclosed in the publication No. 6-257533, an auxiliary valve held slidably in an auxiliary valve chamber is energized electromagnetically to control a pressure in the back pressure chamber by opening and closing a path between the back pressure chamber and the auxiliary valve chamber. Also a piston of a suction check valve body slides in a suction check valve chamber according a pressure difference between a pumping chamber section connected to a fuel path and the back pressure chamber and an energizing force of the suction check valve spring, and the check valve body opens and closes

a path between the back pressure chamber and a pumping chamber. Then an effective force-feed stroke is adjusted by the adjustment of the suction check valve closing timing of the check valve body.

DISCLOSURE OF THE INVENTION

However, for example, in cases where operating conditions may remarkably change during the engine operating time, or where a high-speed rotation and an increase in a high pump pressure up to 200 ~ 400 MPa are required, or where a larger volume discharge pump or an increases in sliding stroke of the suction check valve body are required, the above described check valve body will require a large solenoid valve to drive directly the auxiliary valve having a large inertia, thereby causes difficulties in a rapid response and stabilization of the actuation of the solenoid valve.

It is an object of the present invention to provide a high-pressure plunger pump suitable for pumping a high-pressure fuel which eliminates the difficulties in the above described conventional high-pressure fuel pump in cases where a larger volume discharge pump or a rapid sliding strokes of the suction check valve body are required. Another object of the present invention is to provide a variable discharge high-pressure plunger pump in which the size of solenoid valve may be minimized, of low frictional wears in the solenoid valve body and its valve seat, of low solenoid valve leak, of a high-speed response, of a low production cost, and enables a precise control of varying a pump discharge rate thereof responding to the fed electric signal to the solenoid valve precisely.

(1) For these aims, in a high-pressure plunger pump which is able to perform a pumping action by having a pump plunger biased by a force of a spring and reciprocable in a cylinder bore formed in a pump housing driven through cam mechanism, a pumping chamber in which the pump plunger pressurizes a fuel, a

suction check valve body disposed in a suction port of the pumping chamber and a discharge check valve disposed in a discharge port of the pumping chamber, characterized in that the high-pressure plunger pump of the present invention has a small back pressure chamber formed within a cup-shaped small back pressure chamber body which closes an end of a slide hole receiving a cylindrical portion of the suction check valve body. The small back pressure chamber has a port hole which communicates between the small back pressure chamber and a feed fuel passage. By opening and closing the port hole of the small back pressure chamber by an actuation of a driving member of a small solenoid valve, the small back pressure chamber is selectively communicated with the feed fuel passage, thereby when the suction check valve body is operated, the driving member of the solenoid valve closes the port hole of the small back pressure chamber responding to an electric signal given in synchronized with the stroke of the pump plunger, an opening valve position of the suction check valve body is adjusted to retain its opening valve position even if the suction check valve body receives forces exerted both by a check valve spring in a closing direction and a fluid pressure of the pumping chamber, thereby an adjustment of varying a pump discharge rate thereof is achieved. Further, the feed fuel passage selectively communicated with the port hole is communicated with the suction port of the pumping chamber through another feed fuel passage, and when the suction check valve body is operated, a feed fuel discharged through the port hole of the small back pressure chamber is discharged to the suction port of the pumping chamber so as to replace the feed fuel inside the small back pressure chamber sequentially with new one.

By such an arrangement of the present invention, since the port hole of the small back pressure chamber body which closes the end of the slide hole receiving the cylindrical portion of the suction check valve body is small, it is possible to strengthen a resisting force exerted by a pilot actuation of the driving member of

the small solenoid valve to close the small port hole against a force which acts to close the suction check valve body caused by the pressure of a compression stroke of the pump plunger in the pumping chamber. And, since the small solenoid valve is minimized, a high-speed response, a low production cost, low solenoid valve leak, and a precise control of varying a pump discharge rate thereof precisely responding to the fed electric signal to the solenoid valve are obtained. In addition, when the suction check valve body is operated, since the feed fuel discharged through the port hole of the small back pressure chamber is discharged to the suction port of the pumping chamber so as to replace the feed fuel inside the small back pressure chamber sequentially with new one, thereby the more precise adjustment of varying the pump discharge rate thereof is achieved.

(2) In the arrangement according to (1), preferably, the small back pressure chamber have an inside diameter smaller than that of the slide hole and have a small volume thereof.

By such an arrangement, by the pilot actuation of the driving member of the small solenoid valve, the resisting force against a force to close the suction check valve body produced by the compression stroke of the pump plunger in the pumping chamber is more strengthened, and the small solenoid valve is more minimized.

(3) In the arrangement according to (2), preferably, a hollow metallic spring retainer is disposed between a seal portion of the pump housing and a seal portion of the suction check valve housing both closing the pumping chamber and and the spring retainer receives a hollow metallic spring acting between the spring retainer and a large diameter portion of the suction check valve body to close thereof. The hollow metallic spring retainer has sealing surfaces on both sides having taper angles which are different from those of the seal portions of the pump housing and

the suction check valve housing to secure a tight seal of the pumping chamber.

By such an arrangement, the volume of the inside sealed portions sealed by both the seal portion of the pump housing and the suction check valve housing in the pumping chamber is made smaller, resulting that a leakage of the pressurized fuel is reduced, further, since each of seal portions is in line contact at both sides of the sealing surfaces of the hollow metallic spring retainer, a machining accuracies such as plane roughness and flatness are not required and a perfect seal is achieved under a smaller seal tightening force.

(4) In the arrangement according to (3), preferably, the hollow metallic spring retainer having sealing surfaces on both sides is made of material which is of milder or defomable than those of the seal portions of the suction check valve housing and the pump housing so as to cause deformations in each seal portions and to more tightly seal the pumping chamber to prevent a lowering of the volume efficiency of the plunger pump.

(5) In the arrangement according to (4), preferably, a diameter of the cylindrical portion of the suction check valve body slidably received in the slide hole has the same diameter with that of the large diameter portion thereof, thereby a machining accuracy is easily obtained.

(6) In the arrangement according to (5), preferably, a hollow seal ring member having sealing surfaces on both sides thereof each having a tapered angle is disposed between the suction check valve housing and the cup-shaped small back pressure chamber body, thereby the small back pressure chamber is more tightly sealed to prevent a lowering of the volume efficiency of the plunger pump.

(7) In the arrangement according to (1) or (3), preferably, the small

solenoid valve is of a normally-open-type (NO) solenoid valve in which the driving member thereof closes the port hole of the small back pressure chamber when the electric signal is ON, and opens the port hole when an electric signal is OFF to communicate between the small back pressure chamber and the feed fuel passage.

By such an arrangement, when the driving member of the small solenoid valve energized by an electric signal fed from an electric control unit (ECU) is in an opened state and the pump plunger is in a suction or backward stroke movement, the small back pressure chamber which closes the end of the slide hole receiving the cylindrical portion of the suction check valve body is communicated with the feed fuel passage. The suction stroke movement to expand the volume of the pumping chamber will cause the suction check valve body to be moved away from the seat portion thereof effected by a differential pressure between the check valve spring force and a minus fluid pressure in the pumping chamber caused by the suction stroke movement, and a fuel is introduced into the pumping chamber. The suction check valve body is adapted to open automatically effected by a preset fixed cracking pressure determined by the check valve spring force which is equal to the differential pressure between the fuel feed pressure and the minus fluid pressure in the pumping chamber. This effects that the influences caused by fuel flows into and out of the port hole of the small back pressure chamber are reduced, thereby the influences caused by fuel flows into and out of the high-pressurized pumping chamber are reduced, and the operations of the suction check valve body are stabilized. Further, this arrangement has another merit that by changing the check valve spring force f, the preset opening/closing timing of the check valve body after the electric signal is fed from the electric control unit (ECU) may be changed.

(8) In the arrangement according to (1) or (3), preferably, the small solenoid valve is of a normally-close-type (NC) solenoid valve in which the driving member thereof opens the port hole of the small back pressure chamber when the

electric signal is ON to communicate the small back pressure chamber with the feed fuel passage, and closes the port hole when the electric signal is OFF.

(9) In the arrangement according to (1) or (3), preferably, by detecting a position of the stroke movement of the pump plunger, and in response to the rotating speed of engines, an electric signal is fed to energize (or, de-energize) the solenoid valve in synchronized with a given preset delay time or timing in the vicinity where a speed of the reciprocating stroke of the pump plunger become maximum, or in the vicinity where a sliding stroke of the suction check valve body become maximum, thereby the driving member of the solenoid valve closes the port hole, so that an opening valve position of the suction check valve body is adjusted to retain its opening valve position.

By such an arrangement, there is a property that a speed of a reciprocating stroke movement of the pump plunger become maximum in the vicinity where a sliding stroke of the suction check valve body become maximum, and in synchronized with a timing in response to the rotating speed of engines, which is called a delay time or timing. By feeding an electric signal to energize (or, de-energize) the solenoid valve in the vicinity where sliding strokes of the suction check valve body become maximum, the driving member of the solenoid valve closes the port hole, so that the opening valve position of the suction check valve body is adjusted to retain its opening valve position. In this time, by detecting a rotational angle of the cam or a position of the stroke of the pump plunger, and feeding an electric signals from the electric control unit (ECU) synchronized with a given delay timing to energize (or, de-energize) the solenoid valve, the driving member of the solenoid valve closes the port hole, thereby enables to vary a pump discharge rate, and also a precise control of varying a pump discharge rate thereof is obtained.

When the driving member of the solenoid valve opens the port hole by

feeding the electric signal to energize (or, de-energize) thereof, the suction check valve body is moved into a sealing engagement with a seat of the suction check valve housing, effected by both a check valve spring force and a pressure in the pump chamber generated by a compression or pumping stroke of the pump plunger, and the pump chamber is sealed. A further compression stroke of the pump plunger will rise the pressure in the pump chamber, and when it rises further than the cracking pressure of the delivery check valve, the pressurized fuel is discharged through the delivery check valve. Since a delay timing to stop the feeding of the electric signals from the ECU may be selected at any timing during the compression stroke of the pump plunger in one's discretion, thereby the control of the variable delivery flow rate becomes possible.

(10) More, preferably, in a high-pressure plunger pump which is able to perform a pumping action by having a pump plunger biased by a force of a spring and reciprocable in a cylinder bore formed in a pump housing driven through cam mechanism, a pumping chamber in which the pump plunger pressurizes a fuel, a suction check valve body disposed in a suction port of the pumping chamber and a discharge check valve disposed in a discharge port of the pumping chamber, characterized in that the high-pressure plunger pump of the present invention has a small back pressure chamber formed within a cup-shaped small back pressure chamber body which closes an end of a slide hole receiving a cylindrical portion of the suction check valve body. The small back pressure chamber has a port hole which communicates between the small back pressure chamber and a feed fuel passage. By opening and closing the port hole of the small back pressure chamber by an actuation of a driving member of a small solenoid valve, the small back pressure chamber is selectively communicated with the feed fuel passage, thereby when the suction check valve body is operated, the driving member of the solenoid valve closes the port hole of the small back pressure chamber responding to an

electric signal given in synchronized with the stroke of the pump plunger, an opening valve position of the suction check valve body is adjusted to retain its opening valve position even if the suction check valve body receives forces exerted both by a check valve spring in a closing direction and a fluid pressure of the pumping chamber, thereby an adjustment of varying a pump discharge rate thereof is achieved. Further, the feed fuel passage selectively communicated with the port hole is communicated with the suction port of the pumping chamber through another feed fuel passage, and when the suction check valve body is operated, a feed fuel discharged through the port hole of the small back pressure chamber is discharged to the suction port of the pumping chamber so as to replace the feed fuel inside the small back pressure chamber sequentially with new one. The small back pressure chamber have an inside diameter smaller than that of the slide hole and have a small volume thereof. Further, a hollow metallic spring retainer is disposed between a seal portion of the pump housing and a seal portion of the suction check valve housing both closing the pumping chamber and the spring retainer receives a hollow metallic spring acting between the spring retainer and a large diameter portion of the suction check valve body to close thereof to secure a tight seal of the pumping chamber. The hollow metallic spring retainer having sealing surfaces on both sides is made of material which is of milder or defomable than those of the seal portions of the suction check valve housing and the pump housing so as to cause deformations in each seal portions and to more tightly seal the pumping chamber to prevent a lowering of the volume efficiency of the plunger pump. The hollow metallic spring retainer has sealing surfaces on both sides having taper angles which are different from those of the seal portions of the pump housing and the suction check valve housing to secure a tight seal of the pumping chamber. A diameter of the cylindrical portion of the suction check valve body slidably received in the slide hole has the same diameter with that of the large diameter portion thereof, thereby a machining accuracy is easily obtained. Further, a hollow seal

ring member having sealing surfaces on both sides thereof each having a tapered angle is disposed between the suction check valve housing and the cup-shaped small back pressure chamber body.

By such an arrangement, the same effects are obtainable as those of having all compositions described in (1) to (6).

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is an enlarged partial sectional view of the main portion of a high-pressure plunger pump according to the first embodiment of the present invention.

Fig.2 is an enlarged partial sectional view of the main portion of a high-pressure plunger pump according to the second embodiment of the present invention.

Fig.3 is a general sectional view of a high-pressure plunger pump according to the third embodiment of the present invention.

Fig.4 is an enlarged partial sectional view of a suction check valve and a small solenoid valve of a high-pressure plunger pump according to the forth embodiment of the present invention.

Fig.5 is an enlarged partial sectional view of a suction check valve and a small solenoid valve of a high-pressure plunger pump according to the fifth embodiment of the present invention.

Fig.6 is a time chart diagrammatically illustrating the concept of delay time/timing.

Fig.7 is a diagrammatic illustration of a prior art common rail type fuel injection system to which the high-pressure plunger pump according to the present invention is applied.

THE BEST MODE CARRYING OUT THE INVENTION

Detailed description of the preferred embodiments will be given hereunder with reference to the attached drawings.

Fig.1 is an enlarged partial sectional view of the main portion of a high-pressure plunger pump 1 according to the first embodiment of the present invention, which is used as a high-pressure fuel pump for a conventional common rail type fuel injection system or an accumulator-type high-pressure generator schematically shown in Fig.7.

In the conventional common rail type fuel injection system shown in Fig.7, a low-pressure fuel feed pump 12 sucks fuel from a fuel tank 11 and discharges it into a high-pressure plunger pump 13. The high-pressure plunger pump 13 pressurizes an introduced fuel up to a high-pressure fuel of 100 MPa which corresponds to a fuel injection pressure, and supplies it to a common rail 16 through a discharge check valve 14 and a discharge pipe 15. A plurality of distribution tubes 17 are coupled to the common rail 16, each distribution tube 17 is connected to an electromagnetic fuel injector 19 associated with cylinders of a diesel engine 18. These electromagnetic injectors 19 inject the high-pressure fuel accumulated in the common rail 16 when electromagnetic control valves 20 are operated and opened, thereby injector needles (not shown) are opened to inject the high-pressure fuel in the common rail 16 into the cylinders of the engine 18. The electromagnetic control valves 20 associated with the injectors 19 are controlled by an electronic control unit (ECU) 21. The ECU 21 includes, for example, an engine rotational speed sensor 22 and a load sensor 23 and receives the information of a rotational speed of the engine 18 and the information of a loaded condition, and judges the operating state of the engine 18, and in comply with the operating state thereof, a control signal which represent the optimum fuel injection timing and the optimum quantity of injection fuel is fed to the electromagnetic control valves 20. Therefore, in comply with the operating state of the engine 18, at the optimum fuel injection timing, the optimum quantity of injection fuel is injected into each

cylinders of the engine 18 through the injector 19. When the pressure of the high-pressure fuel in the common rail 16 is dropped by a consumed fuel injected by the injector 19, the consumed fuel must be supplied and the pressure of the high-pressure fuel in common rail 16 must be maintained at the preset injection pressure. Therefore, the consumed fuel is supplied from the high-pressure plunger pump 13 into the common rail 16. For this aim, a pressure sensor 24 which detect a fuel pressure in the common rail 16 is associated therewith, and in response to the signal from the ECU, a command signal is produced and fed to the high-pressure plunger pump 13, thereby a high-pressure pressurized fuel from the plunger pump 13 is supplied. Therefore, the high-pressure pumps of this kind described in each prior art have adopted devises to control pump discharge rate thereof in comply with the load and the rotational speed of the engine.

The high-pressure plunger pump 1 according to the first embodiment of the present invention shown in Fig.1 is able to perform a pumping action by having a pump plunger 3 biased by a force of a spring (not shown) and reciprocable in a cylinder bore formed in a pump housing 50 driven through a cam mechanism (not shown), a pumping chamber 2 in which the pump plunger 3 pressurizes a fuel, a suction check valve body 51 disposed in a suction port 26 of the pumping chamber 2 communicated with a feed fuel passage 4 and a discharge check valve 30 disposed in a discharge port 27 of the pumping chamber 2.

The high-pressure plunger pump 1 has a small back pressure chamber 62 formed within a cup-shaped small back pressure chamber body 6 which closes an end of a slide hole 52 of the suction check valve hausing 50 receiving the suction check valve body 51. The small back pressure chamber body 51 has a port hole 61 which communicates between the small back pressure chamber 62 and a feed fuel passage 4. In this embodiment, the small back pressure chamber 62 has an inside diameter smaller than that of the slide hole 8. By opening and closing the port hole 61 of the small back pressure chamber 62 through an actuation of a

driving member or rod 71 of a small solenoid valve 7, the small back pressure chamber 62 is selectively communicated with the feed fuel passage 4. The small solenoid valve 7 has a solenoid coil 72, a fixed magnetic stator 73 fixed to a pressure-resistant tube 76, a magnetic armature 74 reciprocable within the tube 76.

When the suction check valve body 51 is operated, responding to an electric signal (not shown) given in synchronized with the strokes of the pump plunger 3, the driving member or rod 71 of the solenoid valve 7 closes the port hole 61 of the small back pressure chamber 62, and an opening valve position of the suction check valve body 51 is adjusted to retain its opening valve position even if the suction check valve body 51 receives forces exerted by a check valve spring 54 in a closing direction and a fluid pressure in the pumping chamber 2, thereby an adjustment of varying a pump discharge rate thereof is achieved. Further, the feed fuel passage 4 selectively communicated with the port hole 61 is communicated with the suction port 26 of the pumping chamber 2 through another feed fuel passage 4, and when the suction check valve body 51 is operated, a feed fuel discharged through the port hole 61 of the small back pressure chamber 62 is discharged to the suction port 26 of the pumping chamber 2 through another feed fuel passage 4 so as to replace the feed fuel inside the small back pressure chamber 62 sequentially with new one.

As seen in Fig.1, a cam, not shown and which is, for example, shown as 64 in Fig.3, is installed in a downward position of the pump housing 50. The check valve body 51 is urged upwardly as seen in Fig.1, by the force exerted by the suction check valve spring 54 guided by a spring guide 53 supported by a snap ring 59 fixed to the suction check valve body 51. Between the cylindrical portion 56 of suction check valve body 51 and the slide hole 8, a small clearance is formed so that a leakage from the small back pressure chamber 62 through the small clearance becomes very slight even if the pressure in the small back pressure chamber 62 rises. The small solenoid valve 7 shown in Fig.1 is of a normally-open type (NO) solenoid valve in which the driving member or rod 71 thereof closes the port hole

61 of the small back pressure chamber 62 when an electric signal is ON, forced by an attracting force between the fixed magnetic stator 73 and the magnetic armature 74 exceeding the force of the solenoid spring 75. On the contrary, when the electric signal is OFF, the driving member or rod 71 is returned upwardly as seen in Fig.1, together with the magnetic armature 74 exerted by the force of the solenoid spring 75 and opens the port hole, thereby communicate the port hole 61 with the feed fuel passage 4.

In operation, before starting the engine, upon setting a keyswitch ON, the feed fuel passage 4 formed in the pump housing 28 is applied with a pressure of about 0.3 MPa generated by a fuel feed pump (not shown) and regulated by a relief valve (not shown). When the pump plunger 3 is moved toward downwardly or a suction stroke direction, a force of a negative or minus pressure in the pumping chamber 2 exceeds the force exerted by the suction check valve spring 54, thereby the fuel is introduced into the pumping chamber 2. When the port hole 61 of small back pressure chamber 62 is opened and while the pump plunger 3 is moved toward upwardly or a compression stroke direction, the large diameter portion 55 of the suction check valve body 51 closes the suction port 26, and a pressurized fuel in pumping chamber 2 pushes and opens the check valve body 32 of the discharge check valve 30, and the pressurized fuel is supplied into the common rail 16 such as shown in Fig.7.

By such an arrangement of the high-pressure plunger pump 1 according to the first embodiment of the present invention, since the port hole 61 of the small back pressure chamber body 6 which closes the end of the slide hole 8 receiving the cylindrical portion 56 of the suction check valve body 51 is small, it is possible to strengthen a resisting force exerted by a pilot actuation of the driving member 71 of the small solenoid valve 7 to close the small port hole 61 against a force which acts to close the suction check valve body 51 caused by the pressure of the compression stroke of the pump plunger 3 in the pumping chamber 2. And, since the small

solenoid valve 7 is minimized, a high-speed response, a low production cost, low valve leak and a precise control of varying a pump discharge rate thereof precisely responding to the fed electric signal to the solenoid valve 7 are obtained. In addition, when the suction check valve body 51 is operated, since the feed fuel discharged through the port hole 61 of the small back pressure chamber 62 is discharged to the suction port 26 of the pumping chamber 2 so as to replace the feed fuel inside the small back pressure chamber 62 sequentially with new one, no air remains within the small back pressure chamber 62, thereby the more precise adjustment of varying the pump discharge rate of the high-pressure plunger pump 1 is achieved.

Referring to Fig.2, there is shown an enlarged partial sectional view of the main portion of a high-pressure plunger pump according to the second embodiment of the present invention. In this embodiment, a hollow metallic spring retainer 88 is disposed between a seal portion 89 of the pump housing 150 and a seal portion 92 of the suction check valve housing 152 to close the pumping chamber 2 and which receives a hollow metallic spring 84 acting between the spring retainer 88 and a large diameter portion of the suction check valve body 151 in a closing direction thereof. The hollow metallic spring retainer 88 has on both sides with sealing surfaces 90、91 each having a taper angle which is different from those of the seal portion 89,92 of the pump housing 150 and the suction check valve housing 152 to secure tight seals therebetween. Since each seal portions 89,92 are in line contact in both sides of the sealing surface 90、91 of the hollow metallic spring retainer 88, machining accuracies such as plane roughness and flatness are not required and a perfect seal is achieved under a smaller seal tightening force.

In the embodiment shown in Fig.2, each sealing surface 90、91 of the hollow metallic spring retainer 88 has taper angles ($25 \sim 45^\circ$) which is larger than any one of the taper angles ($2 \sim 10^\circ$) of the seal portions 89、92 of the pump housing 150

and the check valve housing 152. And by a tightening force to be applied to screws 93 formed on the check valve housing 152, the pump housing 150 seals the seal portions 89、92 of the pump housing 150 and the check valve housing 152. Material hardness (300～400 HV) of the hollow metallic spring retainer 88 is made lower than those (1000 HV) of the seal portions 89、92 of the suction check valve housing 152 and the pump housing 150 so as to cause deformations in each seal portions 89、92 to more tightly seal the pumping chamber 2 to prevent a lowering of the volume efficiency of the plunger pump 1.

Fig.3 shows a general sectional view of a variable discharge high-pressure plunger pump according to the third embodiment of the present invention. In this embodiment, except that a diameter of a cylindrical portion 256 of a suction check valve 205 slidably received in a slide hole 208 of a suction check valve housing 252 has the same diameter as that of a large diameter portion 155 thereof, the suction check valve body 251 has the same arrangement as those of the suction check valve 105 shown in Fig.2. Pump plungers 3 are each reciprocably received in cylinder bores 66 formed in a pump housing 250, a rotational movement of a cam 64 fixed on a shaft 63 is converted into a rectilinear movement when the cam 64 is rotated. When the shaft 63 is rotated by an external power source not shown, an outer ring 165 is rotated via a bearing 65 fixed to the cam 64, and the pump plungers 3 slidably contacted with the bearing 65 perform reciprocating movements within the cylinder bores 66. A stroke of the pump plunger 3 is determined by a cam profile of each cam surface. Reference numerals 12 and 67 denote a fuel supply pump and a relief valve, respectively. Since the diameter of the cylindrical portion 256 of the suction check valve body 251 received in the slide hole 208 of the suction check valve housing 252 is made equi-diametral with these of the large diameter portion 255 thereof, a machining accuracy is easily obtained. The pump plunger 3 appearing at the upper side of the Fig.3 is in a bottom dead point position and a fuel in the pumping chamber 2 is in a state before a compression is applied.

The pump plunger 3 appearing at the bottom side of the Fig.3 is in a top dead point position and the pressure of the fuel in the pumping chamber 2 has a remaining pressure which is generated after the pressurized fuel in the pumping chamber 2 is discharged through the discharge port 27 and the discharge check valve 30. In this position, the large diameter portion 255 of the suction check valve body 251 sits on the seat portion of the suction check valve housing 252 and closes the discharge port 27. In this situation, no electric signal from the ECU 21 is applied and the port hole 61 of the small back pressure chamber 62 is opened, and the fuel in the small back pressure chamber 62 is communicated with the feed fuel passage 4.

When the pump plunger 3 appearing at the bottom side of the Fig.3, starts an upward or suction stroke, then the volume of the pumping chamber 2 is increased and the pressure of in the pumping chamber 2 is lowered, and becomes lower than the pressure of the fuel in the suction port 27. And when the differential pressure between those two pressures exceeds the preset cracking pressure of the suction check valve 205 preset by a force of the suction check valve spring 254, the suction check valve body 251 is opened. The large diameter portion 255 of the suction check valve body 251 moves away from the seat portion of the suction check valve housing 252, and the fuel in the suction port 27 is introduced into the pumping chamber 2. When the suction stroke of the pump plunger 3 continues, the cylindrical portion 256 of the suction check valve body 251 will reach to its maximum stroke in the vicinity where the speed of the reciprocating stroke movement of the pump plunger 3 become maximum. By feeding an electric signal to energize the solenoid valve 7 at a timing when the sliding stroke of the suction check valve body 251 becomes maximum, the driving member of the solenoid valve 7 closes the port hole 61 of the small back pressure chamber 62, and the opening valve position of the suction check valve body 251 is retained its opening valve position. That is, detecting the stroking position of the pump plunger 3, in the vicinity where the speed of the reciprocating stroke movement of the pump plunger

3 become maximum or in the vicinity where the cylindrical portion 256 of the suction check valve body 251 reaches to its maximum stroke, an electric signal is fed after a given delay timing preset in response to the rotating speed of engines to energize (or de-energize) the solenoid valve, thereby the large diameter portion 255 of the suction check valve body 251 retains its opening valve position.

Here, the timing means a time point responding to the stroking position of the pump plunger during the stroke movement thereof, and which is possible by detecting a rotation angle of the camshaft or a stroking position of the pump plunger as an electric signal, and by processing the electric signal, the responding rotation angle of the camshaft or the stroking position of the pump plunger is possible to identify. Examples of the delay time is shown in Fig.6 which shows a one(1) complete repetition of a suction process and a compression process of the pump plunger. Fig.6(1) shows the concept of the repetition of the suction stroke or process and the compression stroke or process of the pump plunger. Displacement is shown as its stroke position. Fig.6(2) shows the concept of an automatic opening/closing of the driving member of the solenoid valve in case the driving member opens when the electric signal is ON and an amount of each displacement X shows that of the suction check valve body. Fig.6(3) shows the opening of the suction check valve body and closing thereof in the vicinity of its largest stroke wherein the driving member of the valve closes the small back pressure chamber in responce to the electric signal fed to the solenoid valve and the suction check valve body is retained in its open condition. Fig.(4) similarly shows those of shown in Fig.6(3), wherein the driving member of the valve closes the small back pressure chamber in responce to the electric signal fed to the solenoid valve in the vicinity where the suction check valve body reaches to its maximum stroke. This shows that by changing ON time (or timing), the rate of the open condition of the suction check valve body may be variably changed.

At a timing when the suction check valve body 251 reached to its largest

stroke, by feeding an electric signal to energize the solenoid valve 7 at a timing when the sliding stroke of the suction check valve body 251 becomes maximum, the driving member of the solenoid valve 7 closes the port hole 61 of the small back pressure chamber 62, and after the plunger pump 3 reaches to its maximum suction stroke, it commences a downward or compression stroke and the volume of the pumping chamber 2 decreases, thereby the pressure therein rises. In this compression process, when the pressure in the pumping chamber 2 exceeds to the combined forces of a force of the feed fuel pressure Pf and the spring force of the suction check valve spring 254, the pressurized fuel in the pumping chamber 2 is spilled through a clearance between the large diameter portion 255 of the suction check valve body 251 and the seat portion of the suction check valve housing 252, and through the suction port 26 into the feed fuel passage 4. The spilled fuel is kept at a constant pressure by the relief valve 67 connected to the feed fuel passage 4. Therefore, the pressurized fuel in the pumping chamber 2 is not adapted to be supplied to the common rail 16 via the discharge port 27 and the discharge check valve if pressurized therein.

Fig.4 is an enlarged partial sectional view of a suction check valve and a small solenoid valve of a high-pressure plunger pump according to the forth embodiment of the present invention, wherein the solenoid valve 41 is of NC-type (normally close-type). In contrast, the solenoid valve 7 shown both in Figs.1 and 3 is of NO-type (normally open-type) in which the driving member 71 thereof closes the port hole 62 of the small back pressure chamber 62 when the electric signal is ON, and opens the port hole 62 when an electric signal is OFF to communicate between the small back pressure chamber 62 and the feed fuel passage 4. And the small solenoid valve 401 shown in Fig.4 is of the NC-type in which the driving member 471 thereof opens the port hole 62 of the small back pressure chamber 62 when the electric signal is ON to communicate the small back pressure chamber 62 with the feed fuel passage 4, and closes the port hole 62 when the electric signal is

OFF. The small solenoid valve 407 has a fixed magnetic stator 473 fixed to the tube 476 and a magnetic armature 474 fixed to the driving member 471. It will be apparent that as the NC-type small solenoid valve 401, similarly to the solenoid valve 7 shown both in Figs.1 and 3, in responce to the fed electric signal, it is possible to control the opening/closing of the check valve body, thereby enables a controlling of varying a pump discharge rate thereof.

Fig.5 is an enlarged partial sectional view of a suction check valve and a small solenoid valve of a high-pressure plunger pump according to the fifth embodiment of the present invention, wherein the suction check valve 505 has a hollow seal ring member 95 having sealing surfaces 97、98 on both sides thereof each having a tapered angle and disposed between the suction check valve housing 252 and the cup-shaped small back pressure chamber body 6. Reference numeral 96 denotes a hollow hole. By such an arrangement, the small back pressure chamber 62 is more tightly sealed to prevent a lowering of the volume efficiency of the plunger pump 1, and a more precise control of varying a pump discharge rate thereof precisely responding to the fed electric signal to the solenoid valve is obtained.

AVAILABILITY IN THE INDUSTRIAL FIELD

According to this invention, a high-pressure plunger pump suitable for a variable discharge high-pressure fuel pump for pumping a high-pressure fuel into an accumulator or a common rail of a common rail type fuel injection system is provided. Since the small solenoid valve is minimized, by a pilot actuation of the small solenoid valve, a high-speed response, a low production cost, low solenoid valve leak, and a precise control of varying a pump discharge rate thereof precisely responding to the fed electric signal to the solenoid valve are obtained. In addition, when the suction check valve body is operated, since the feed fuel discharged through the port hole of the small back pressure chamber is discharged to the suction port of the pumping chamber so as to replace the feed fuel inside the small

back pressure chamber sequentially with new one, the more precise adjustment of varying the pump discharge rate thereof is achieved.

CLAIMS

1. In a high-pressure plunger pump which is able to perform a pumping action by having a pump plunger (3) biased by a force of a spring (9) and reciprocable in a cylinder bore formed in a pump housing (50) driven through cam mechanism (9), a pumping chamber (2) in which the pump plunger (3) pressurizes a fuel, a suction check valve body (51、151、251) disposed in a suction port (26) of the pumping chamber (2) and a discharge check valve (30) disposed in a discharge port (27) of the pumping chamber (2),

characterized in that the high-pressure plunger pump has a small back pressure chamber (62) formed within a cup-shaped small back pressure chamber body (6) which closes an end of a slide hole (8、108、208) of a suction check valve housing (52、152、252) receiving a cylindrical portion (56、156、256) of the suction check valve body (51、151、251),

the small back pressure chamber (62) has a port hole (61) which communicates between the small back pressure chamber (62) and a feed fuel passage (4), by opening and closing the port hole (61) of the small back pressure chamber (62) by an actuation of a driving member (71、471) of a small solenoid valve (7、407), the small back pressure chamber (62) is selectively communicated with the feed fuel passage (4), thereby when the suction check valve body (51、151、251) is operated, the driving member (71、471) of the small solenoid valve (7、407) closes the port hole (61) of the small back pressure chamber (62) responding to an electric signal given in synchronized with the stroke of the pump plunger (3), an opening valve position of the suction check valve body (51、151、251) is adjusted to retain its opening valve position even if the suction check valve body (51、151、251) receives forces exerted both by a check valve spring (54、154、254) in a closing direction and a fluid pressure of the pumping chamber (2), thereby an adjustment of varying a pump discharge rate thereof is achieved, and

the feed fuel passage (4) selectively communicated with the port hole (61) is communicated with the suction port (26) of the pumping chamber (2) through another feed fuel passage (4), and when the suction check valve body (51、151、251) is operated, a feed fuel discharged through the port hole (61) of the small back pressure chamber (62) is discharged to the suction port of the pumping chamber (26) so as to replace the feed fuel inside the small back pressure chamber (62) sequentially with new one.

2. The high-pressure plunger pump according to claim 1, characterized in that, said small back pressure chamber (62) have an inside diameter smaller than that of the slide hole (8、108、208) and have a small volume thereof.

3. The high-pressure plunger pump according to claim 2, characterized in that, a hollow metallic spring retainer is disposed between a seal portion (89) of the pump housing (150、250) and a seal portion (92) of the suction check valve housing (152、252) both closing the pumping chamber (2) and the spring retainer (88、255) receives a hollow metallic spring (84) acting between the spring retainer (88、255) and a large diameter portion (155、255) of the suction check valve body (151、251) to close thereof, said hollow metallic spring retainer (88、255) has sealing surfaces (90、91) on both sides having taper angles which are different from those of the seal portions (89、92) of the pump housing (152、252) and the suction check valve housing (52、152、252) to secure a tight seal of the pumping chamber (2).

4. The high-pressure plunger pump according to claim 3, characterized in that, said hollow metallic spring retainer (88、255) having sealing surfaces (90、91) on both sides is made of material which is of milder or defomable than those of the seal portions (89、92) of the suction check vàlve housing (152、252) and the pump housing (150、250) so as to cause deformations in each seal portions (89、92) and to

more tightly seal the pumping chamber (2).

5. The high-pressure plunger pump according to claim 4, characterized in that, a diameter of said cylindrical portion (256) of the suction check valve body (151、251) slidably received in the slide hole (208) has the same diameter with that of the large diameter portion (255) thereof,

6. The high-pressure plunger pump according to claim 5, characterized in that, a hollow seal ring member (95) having sealing surfaces (97、98) on both sides thereof each having a tapered angle is disposed between the suction check valve housing (252) and the cup-shaped small back (6).

7. The high-pressure plunger pump according to claim 1 or claim 3, characterized in that, said small solenoid valve (7) is of a normally-open-type (NO) solenoid valve in which the driving member (71) thereof closes the port hole (61) of the small back pressure chamber (62) when the electric signal is ON, and opens the port hole (61) when an electric signal is OFF to communicate between the small back pressure chamber (62) and the feed fuel passage (4).

8. The high-pressure plunger pump according to claim 1 or claim 3, characterized in that, said small solenoid valve (407) is of a normally-close-type (NC) solenoid valve in which the driving member thereof opens the port hole of the small back pressure chamber when the electric signal is ON to communicate the small back pressure chamber with the feed fuel passage, and closes the port hole when the electric signal is OFF.

9. The high-pressure plunger pump according to claim 1 or claim 3, characterized in that, by detecting a position of the stroke movement of said pump

plunger (3), and in response to the rotating speed of engines, an electric signal is fed to energize (or, de-energize) the solenoid valve (7、407) in synchronized with a given preset delay time or timing in the vicinity where a speed of the reciprocating stroke of the pump plunger (3) become maximum, or in the vicinity where a sliding stroke of the suction check valve body (51、151、251) become maximum, thereby the driving member (71、471) of the solenoid valve (7、407) closes the port hole (61), so that an opening valve position of the suction check valve body (51、151、251) is adjusted to retain its opening valve position.

10. In a high-pressure plunger pump which is able to perform a pumping action by having a pump plunger (3) biased by a force of a spring (9) and reciprocable in a cylinder bore (66) formed in a pump housing (50) driven through cam mechanism (9), a pumping chamber (2) in which the pump plunger (3) pressurizes a fuel, a suction check valve body (51、151、251) disposed in a suction port (26) of the pumping chamber (2) and a discharge check valve (30) disposed in a discharge port (27) of the pumping chamber (2),

characterized in that the high-pressure plunger pump has a small back pressure chamber (62) formed within a cup-shaped small back pressure chamber body (6) which closes an end of a slide hole (8、108、208) of a suction check valve housing (52、152、252) receiving a cylindrical portion (56、156、256) of the suction check valve body (51、151、251),

the small back pressure chamber (62) has a port hole (61) which communicates between the small back pressure chamber (62) and a feed fuel passage (4), by opening and closing the port hole (61) of the small back pressure chamber (62) by an actuation of a driving member (71、471) of a small solenoid valve (7、407), the small back pressure chamber (62) is selectively communicated with the feed fuel passage (4), thereby when the suction check valve body (51、151、251) is operated, the driving member (71、471) of the small solenoid valve (7、407)

closes the port hole (61) of the small back pressure chamber (62) responding to an electric signal given in synchronized with the stroke of the pump plunger (3), an opening valve position of the suction check valve body (51、151、251) is adjusted to retain its opening valve position even if the suction check valve body (51、151、251) receives forces exerted both by a check valve spring (54、154、254) in a closing direction and a fluid pressure of the pumping chamber (2), thereby an adjustment of varying a pump discharge rate thereof is achieved,

the feed fuel passage (4) selectively communicated with the port hole (61) is communicated with the suction port (26) of the pumping chamber (2) through another feed fuel passage (4), and when the suction check valve body (51、151、251) is operated, a feed fuel discharged through the port hole (61) of the small back pressure chamber (62) is discharged to the suction port of the pumping chamber (26) so as to replace the feed fuel inside the small back pressure chamber (62) sequentially with new one.

further, said small back pressure chamber (62) have an inside diameter smaller than that of the slide hole (8、108、208) and have a small volume thereof,

a hollow metallic spring retainer (88、255) is disposed between a seal portion (89) of the pump housing (150、250) and a seal portion (92) of the suction check valve housing (152、252) both closing the pumping chamber (2) and which receives a hollow metallic spring (84) acting between the spring retainer (88、255) and a large diameter portion (155、255) of the suction check valve body (151、251) to close thereof, said hollow metallic spring retainer (88、255) has sealing surfaces (90、91) on both sides having taper angles which are different from those of the seal portions (89、92) of the pump housing (152、252) and the suction check valve housing (152、252) to secure a tight seal of the pumping chamber (2),

said hollow metallic spring retainer (88、255) having sealing surfaces (90、91) on both sides is made of material which is of milder or defomable than those of the seal portions (89、92) of the suction check valve housing (152、252) and the

pump housing (150、250) so as to cause deformations in each seal portions (89、92) and to more tightly seal the pumping chamber (2),

a diameter of said cylindrical portion (256) of the suction check valve body (151、251) slidably received in the slide hole (208) has the same diameter with that of the large diameter portion (255) thereof,and

a hollow seal ring member (95) having sealing surfaces (97、98) on both sides thereof each having a tapered angle is disposed between the suction check valve housing (252) and the cup-shaped small back (6).

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP00/01746

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl^7 F02M59/34, 59/44, 59/46, 51/00, F04B49/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl^7 F02M59/34-36, 51/00, 59/44-46, 51/00,
F04B49/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Kokai Jitsuyo Shinan Koho	1971-2000	Jitsuyo Shinan Toroku Koho	1996-2000

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 6-257533, A (Nippon Denso Co., Ltd.), 13 September, 1994 (13.09.94), Par. Nos. [0017] to [0026]; Figs. 3 to 5 (Family: none)	1-2,7-8
Y	Microfilm of the specification and drawings annexed to The request of Japanese Utility Model Application No.54283/1986 (Laid-open No.166379/1987), (Kayaba Kogyo K.K.), 22 October, 1987 (22.10.87); Figs. 1,5	1-2,7-8
A	Microfilm of the specification and drawings annexed to The request of Japanese Utility Model Application No.73407/1973 (Laid-open No.20962/1975), (Komatsu Ltd.), 10 March, 1975 (10.03.75), page 1, line 5 to page 2, line9; Fig. 2	3-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
05 June, 2000 (05.06.00)	20 June, 2000 (20.06.00)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.